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JANUARY 11, 1988

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News of the Week

■ **Failure of latest solid rocket booster test firing means NASA will be forced to postpone shuttle flights, scheduled to resume June 2.** **Page 4**

■ **Carl S. Marvel, one of the pioneers of synthetic polymer chemistry, died last week in Tucson, Ariz., at age 93.** **Page 5**

■ **Swiss pharmaceuticals giant Hoffmann-La Roche launches an unfriendly $4.2 million takeover bid for Sterling Drug.** **Page 5**

■ **Waste Management Inc. gives up on seeking EPA permission to burn hazardous wastes off the U.S. coast after six-year effort.** **Page 5**

■ **Sites in eight states are chosen as finalists in race for Superconducting Super Collider.** **Page 6**

■ **Testing of compounds to replace chlorofluorocarbons will intensify as 13 companies from around the world agree to more rigorous series of toxicity tests and pooling of information.** **Page 6**

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Business

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Science

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Stratospheric ozone has decreased globally, not just over Antarctica, according to a new analysis of satellite data. **Page 21**

Technology

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Books

Two books on 1984 lethal chemical leak in Bhopal, India, raise the level of insight on the tragedy. **Page 24**

News Focus

The second session of the 100th Congress will face a number of issues of importance to the chemical community, including biotechnology policy, use of alternative fuels in automobiles, reauthorization of pesticide and waste laws, AIDS testing, and product liability. **Page 7**

Chemical & Engineering News

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LETTERS

National Chemistry Day

SIR: I am sure that stories will slowly be filtering in about things that occurred on National Chemistry Day that were a bit unusual. I could not resist passing this story along to you to share with fellow chemists.

About six years ago a lovely young couple, Angelina and Anthony, graduated from Pace University in New York, both having majored in chemistry. They married soon after graduation and they both went to graduate school at Rutgers University. Last year they both were awarded Ph.D. degrees in organic chemistry after working for the same research adviser. Now comes word that they have been blessed with their first child, Nicole Lucille, born Nov. 6, 1987, on National Chemistry Day. Since Tony is a real fan of chemacrostics (see back cover of *Chemtech*, September 1987), it did not escape our attention that the first two letters of the child's name represent the chemical symbols for nickel and lutetium.

John B. Sharkey
Chairman, Department of Chemistry and Physical Sciences
Pace University

Human visual range

SIR: Recently my attention was directed to an article entitled "The Chemistry of Vision" by Pamela S. Zurer (C&EN, Nov. 28, 1983, page 24). Although this was four years ago, I would like to comment favorably on the well-organized and clearly written article. The essence of my comments concerns the tremendous range in brightness the human visual system is capable of. In order to set the stage properly, allow me to quote the first paragraph. "The human sense of sight is exquisitely sensitive and adaptable. A person whose eyes have adjusted to darkness can sense the dimmest of light—less than 100 photons. Yet the same person needs only a minute to adjust to brilliant sunshine without being blinded. No man-made photographic system can function under such extremes." Then in the seventh paragraph I again quote, "Humans can see over a range of brightness covering six or seven powers of 10. Most of the process of adapting to changing light itensity occurs in the retina."

In the late 1950s, I invented a silver halide photographic film called XR for extended range for the express purpose of technical and scientific photography of nuclear explosions. Because the cameras used were of the remote automatic type, usually operated at high framing rates, it was not feasible to use mechanically adjustable exposures. Thus the film itself, disclosed in U.S. patent No. 3,450,536 and made by Eastman Kodak, had to contain the ability of recording over a tremendous brightness range of nine powers of 10 or a billion to one.

The inherent brightness range capability could easily have been increased by many more powers of 10. However, it seemed to be adequate for the intended purpose of recording a blinding flash exceeding that of the sun by a thousand times during one instant and then continuing to record a moment later the extremely low level recombination purplish light as faint as a luminous watch dial. (See *Life Magazine*, Dec. 23, 1966, page 112.) This special film was a so-called panchromatic black and white recording medium, whereas the remarkable human visual system produces a color sensation that is far more complex. However, using the principles involved in this film, I did invent a natural color film for the National Aeronautics & Space Administration and the Apollo moon landing program that had a response of six powers of 10 (see U.S. patents, No. 3,663,228; 3,812,507; and 3,849,138). This film has served as the model for Kodak's newer and much improved multi-multilayer color films.

Charles W. Wyckoff
Founder and Chairman of the Board
Brite-Line Corp., Boston

Benzene exposure

SIR: As reported in your article (C&EN, Sept. 7, 1987, page 7) and elsewhere, the Occupational Safety & Health Administration has finally recognized the inordinate risk of leukemia and other blood disorders due to benzene exposure in the workplace. A 90% reduction in workplace exposure, to 1 ppm over eight hours, has been ordered.

Although long-term workplace exposure is and continues to be a serious problem, research chemists should be alerted to the dire long-term consequences of even brief exposure to high levels of benzene (spillages, reaction runaways, etc.) by skin contact or inhalation.

The study by the National Institute for Occupational Safety & Health [*N. Engl. J. Med.*, **316**, 1044 (1987)] reported that rubber industry workers exposed to benzene vapors at levels of 10 ppm of air (the federal standard until September 1987) faced a threefold risk of leukemia

Continued on page 32

Federal 1989 budget proposal delayed

The Administration was supposed to submit its fiscal 1989 budget proposal to Congress on Jan. 5, but what Congress got instead was a letter from Office of Management & Budget director James C. Miller III saying that "I do not see any way to prepare a responsible budget proposal for transmittal before mid-February." The delay stems from Congress' not concluding final appropriation actions and reconciliation for fiscal 1988 until just before Christmas. Miller pointed out that OMB and the departments and agencies must now translate hundreds of pages of an omnibus continuing resolution and an omnibus budget conciliation bill into the precise detail necessary for a 1988 budget. That task has to be accomplished before the job of developing detailed information for a new set of fiscal 1989 budget proposals can be started.

Company convicted of environmental crimes

A Denver-based company, Protex Industries, has been convicted of violating federal laws by illegally endangering human life through the improper treatment and disposal of hazardous wastes. The Justice Department claims this is the first conviction ever under a law passed last year against endangerment of human life through treatment of wastes. The company was found guilty of three counts of knowing endangerment during the operation of a drum recycling operation. Fines can equal $1 million for each count. Three employees were exposed to residues of pesticides, including chlordane, and industrial solvents. Protex did not inform the workers of the hazards or train them or equip them to avoid exposures. The president of Protex still faces 11 charges of misconduct, including 10 counts of illegally storing or disposing of hazardous wastes. The investigation was conducted by EPA's National Enforcement Investigations Center and the Federal Bureau of Investigation.

Grapes still must be certified sulfite-low

Claiming there hasn't been enough time to consider all the alternatives, EPA has extended the year-old certification program for sulfites in grapes for another year. The current regulation, established in December 1986, requires that grapes imported or shipped in interstate commerce be certified to contain no detectable residues of sulfites (less than 10 ppm). Sulfiting agents (sulfur dioxide or sodium metabisulfite) used to prevent mold growth on grapes have been linked to allergic reaction in some consumers. FDA removed sulfites from its Generally Recognized As Safe designation in 1986, forcing EPA to reconsider its previous position of not needing a tolerance level. Grape producers have asked EPA to allow the continued use of low levels of sulfiting agents as long as the products are labeled as containing sulfites. EPA is considering this and other ideas.

Tougher standards for animal drug residues

Developers of new animal drugs will be required to establish analytical tests for detecting those drugs in animal tissue under new regulations proposed last week by FDA. The rule applies to any veterinary drug that is potentially carcinogenic. The test protocol must be sent to FDA with the drug's safety data and should be sufficiently sensitive to reveal a level of residue that would result in a maximum lifetime cancer risk of one in a million, FDA says. The previous standard for drug residues was a flat 2 ppb. In addition to the drug test, animal drug manufacturers must also present data on laboratory animal cancer testing, metabolic products in the animal, and where the residues remain in the body.

Use of CFC-22 allowed in food packaging

FDA has given Du Pont permission to market CFC-22 as a blowing agent for food packaging. Du Pont has developed new technology that allows CFC-22, which it calls Formacel-S, to be used in the production of plastic foams. Formacel-S replaces CFC-12, a vigorous depleter of stratospheric ozone. Because it is a hydrogen-containing compound, Formacel-S will reduce the potential for ozone depletion by 95% compared with CFC-12, Du Pont claims. The compound is less stable than CFC-12 and breaks down before reaching the stratosphere. It is not photochemically reactive or flammable, is low in toxicity and is chemically inert. FDA has allowed Du Pont to use Formacel-S in fast food containers. Du Pont is now seeking FDA's permission to use it in poultry and meat trays, and egg cartons. Formacel-S is more expensive than CFC-12, but lesser amounts of it are required to produce plastic foam packages.

Washington roundup

- Figures for the Department of Energy's R&D budgets were stated incorrectly in C&EN's article last week about the fiscal 1988 federal budget (Jan. 4, page 6). The total budget is up 6%, not 21%, to $4.9 billion. The energy R&D budget is up 6%, not 31%, to $3.4 billion; basic energy sciences is up 7%, not 20%, to $564.6 million; and weapons R&D and testing is up 7%, not 1%, to $1.5 billion.
- The Commerce Department is inviting suppliers of pollution control equipment to apply on a "first-come" basis for a trade mission to the Netherlands, West Germany, and Italy, May 15–25. For details, contact Jay Brandes, International Trade Administration, U.S. Department of Commerce, Room H2805, Washington, D.C. 20230, or phone (202) 377-0560.
- EPA has begun requiring that risk-reduction measures be added to the product label of the herbicide cyanazine as a condition for continued use and sale. The agency has determined that exposure may result in unreasonable risk to persons mixing, loading, and applying this chemical.

Low Health Risk Seen For Dioxin in Paper Products

Study finds skin exposure to TCDD in paper goods to be far below hazardous levels; work is under way on paper dust, food packaging

Last September, the Environmental Protection Agency and the paper industry announced that small amounts of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) are present in pulp, wastewater, and sludge from paper mills. Of more pressing concern to the public, TCDD also appears in paper products to which consumers are exposed daily (C&EN, Oct. 5, 1987, page 19).

Not to worry, says the American Paper Institute. API has just released a study assessing potential health risks from dermal exposure to TCDD in paper products made from bleached pulp. The 130-page report finds that "any risk to consumers from normal use of products may be as low as zero and is considerably less than the one-in-a-million risk level used by the government to determine a virtually safe dose." The risk assessment, the only published review on the subject, was sponsored by the industry's environmental and research arm, the National Council of the Paper Industry for Air & Stream Improvement (NCASI), and was conducted by Envirologic Data Inc.

NCASI also is studying potential health threats from two other exposures: inhalation of paper dust, and ingestion of TCDD from food packaging and food contact products (such as coffee filters). In a few weeks, it will issue results of studies on TCDD in dust at workplaces doing much paper cutting.

As for food contact products, NCASI has released a preliminary report, finding no migration of TCDD out of packaging, and very low migration of a related but less potent furan—2,3,7,8-tetrachlorodibenzofuran (TCDF). However, the study must solve some basic analytical questions, such as finding suitable food-simulating liquids. The study will also collect the most extensive database available on paper products in contact with food.

TCDD and TCDF are formed as trace contaminants in paper mills during bleaching of kraft pulps with chlorine and chlorine derivatives to make white products. The bleaching process varies among mills, producing varying TCDD and TCDF levels. In a study of seven pulps, for example, TCDD levels ranged from nondetectable (below the detection limit of 1.0 ppt) to 51 ppt, with a median of 4.9 ppt. How TCDD and TCDF are formed chemically is not yet known, but studies are under way, notes Michael C. Farrar, API vice president for environmental and health affairs.

NCASI's assessment of the health risk from dermal exposure to TCDD defines "virtually safe" levels in various paper products, expressing them as the TCDD concentrations in bleached pulp yielding a lifetime cancer risk of one in a million. TCDD has been shown to cause cancer in animals, but a causal link for humans has not yet been established. Nevertheless, notes Dwain Winters, chief of the policy staff in EPA's office of toxic substances, his agency considers TCDD to be a "probable human carcinogen."

The NCASI study uses data on migration, transfer, absorption, and bioavailability of TCDD and its

Skin exposure to TCDD in paper products found negligible

	Safe level calculated TCDD,[a] ppt		Level measured TCDD, ppt
	Female	Male	
Bleached pulps			5[b]
Communication paper			13[c]
Clerical worker	9,000	9,100	
Manager	4,200	4,300	
Personal care products			
Disposable diapers			0[d]
Conventional	540,000	540,000	
Superabsorbent	2,000,000	2,000,000	
Facial tissue			
Normal use	66,000,000	79,000,000	
Makeup	230,000		
Toilet tissue	27,000,000	65,000,000	
Sanitary pads	63,000,000		
Paper towels	7,900,000	9,500,000	4
Composite personal care products[e]	160,000	510,000	
Combined communication papers-personal care products			
Clerical worker	8,500	8,900	
Manager	4,100	4,200	

a Virtually safe concentration of 2,3,7,8- tetrachlorodibenzo-*p*-dioxin (TCDD) equivalents in pulp, corresponding to a 1×10^{-6} cancer risk, at lower 95% statistical confidence bound. b Measured in seven pulps, with levels from not detectable (detection limit of 1.0 ppt) to 51 ppt, and a median of 4.9 ppt. c Measured in bond paper. d No TCDD detected in disposable diapers, at detection limits of 2.1 and 2.6 ppt. e Excluding superabsorbent disposable diapers.
Source: National Council of the Paper Industry for Air & Stream Improvement

equivalents from bleached pulp-based products to estimate what human uptake of TCDD would be from contact with skin. Models for each paper product enable calculation of potential exposure to TCDD over a working lifetime.

Calculations for communication papers (for writing, typing, books, and newspapers, excluding coated stock) show that levels ranging from 4200 ppt TCDD for female managers to 9100 ppt for male clerical workers would be considered virtually safe. For personal care products, safe levels range from 230,000 ppt for female use of facial tissues for makeup removal to 79 million ppt for normal use of facial tissue by males. Paper towels have safe levels of 7.9 million ppt for females, 9.5 million ppt for males.

By contrast, actual measurements find just 13 ppt of TCDD in bond paper, 4 ppt in paper towels, and no detectable level in disposable diapers (detection limits of 2.1 and 2.6 ppt). Thus, actual TCDD levels are orders of magnitude less than the concentrations estimated to be safe.

The paper industry's studies so far on TCDD in paper are "commendable," says Ellen K. Silbergeld, a toxicologist with the Environmental Defense Fund. However, she notes, there are so many other exposures that a more general approach should be taken, going after the upper and lower risk limits. She urges an upper limit of 10 ppt TCDD in paper for food-related uses.

EPA, for its part, will be evaluating the report on dermal exposure—and looking at partition coefficients or migration potential from paper products to humans—to determine whether there is a risk to be regulated. EPA leads an interagency group that includes the Food & Drug Administration and the Consumer Product Safety Commission, Winters notes. EPA also will survey the more than 100 U.S. paper mills for TCDD in pulp, wastewater, and sludge. If there is a hazard in disposal of wastewater or sludge, or in use of paper products, it would be best handled by changing the bleaching process to eliminate TCDD formation, he stresses.

Richard Seltzer, Washington

New color technology uses microcapsules

Mead Imaging has high hopes for a new color reproduction technology it has developed and calls Cycolor. Mead Imaging president Charles W. Joiner Jr. says that the technology is simple and cost-effective enough that color reproduction need no longer be an expensive luxury. "Instead," he says, "color can become the standard for all business communications."

Cycolor is a color, photographic-like, film technology. No silver halide is used, and the film is sensitive to visible light.

Calling Cycolor a major breakthrough in color-imaging technology, Joiner says that it will make possible the development of office equipment that would bring the graphic impact of color to everyday business communications. Using the new process, he explains, companies would be able to make the use of color hard copy and overhead transparencies standard business practice.

That, at least, is Mead Imaging's hope. The company was formed in 1984 as a division of Mead Corp., a forest products and electronic publishing company headquartered in Dayton, Ohio. Its mission was to develop and commercialize a new color-imaging technology based on light-sensitive microcapsules.

The resulting technology makes use of a film coated with such microcapsules, called cyliths, that are on the order of 5 μm in diameter. These are sensitive to red, green, and blue light, so that, when the film is exposed to light, a latent image is produced. The latent image is a pattern made up of exposed and nonexposed cyliths.

Each cylith contains a liquid monomer. Dissolved in the monomer is a light-sensitive photoinitiator and a color-forming substance called a leuco dye, which is colorless until it reacts. Exposure of the film to light causes the cyliths to harden in proportion to the amount of exposure, making them resistant to rupture. The latent image is thus formed by hard (exposed) and soft (not exposed) cyliths.

For development, the Cycolor film and Cycolor paper or transparency material are compressed together through a set of pressure rollers. Unexposed cyliths release dyes to the paper or transparency, and the dyes react with the coating on either to produce a color image. In a final step, the paper or transparency is heated briefly to enhance the quality of the color reproduction.

Full color is achieved through use of a mixture of three different types of cyliths coated on the film in a single layer. The three contain either cyan, magenta, or yellow leuco dyes, along with the photoinitiators, which are sensitive to red, green, or blue light, respectively. Exposure to red light, for example, hardens the capsules containing cyan dye, and pressure on the cylith capsules causes the release of magenta and yellow dyes, which mix to form a red image. Likewise, exposure to green light controls the magenta dye, with development resulting in cyan and yellow dyes mixing to form a green image. In a similar manner, blue light controls the yellow dye. Exposure of all cyliths (white light) results in no color (white), and exposure of none of the cyliths results in black. Any color can be reproduced, Mead Imaging explains, by controlling the relative proportion of the three dyes.

Mead Imaging sees a number of markets for the Cycolor technology and is working with other firms that are developing the hardware to employ it. One use, for example, is in color copiers. Another is in 35-mm slide printers, providing a simple and inexpensive way to create hard copy prints from 35-mm slides used in business presentations. A third use is in color computer printers, which would have desktop publishing, scientific, technical, and general business applications. Also, Mead Imaging points out, Cycolor technology works effectively with a variety of digital imaging techniques. For example, it meets the need, the company says, for high-quality, low-cost hard copies of images produced by electronic cameras.

James Krieger, Washington